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Final Report
NAG3-1648
Collaboration on SEP Missions to the Moon and Small Bodies

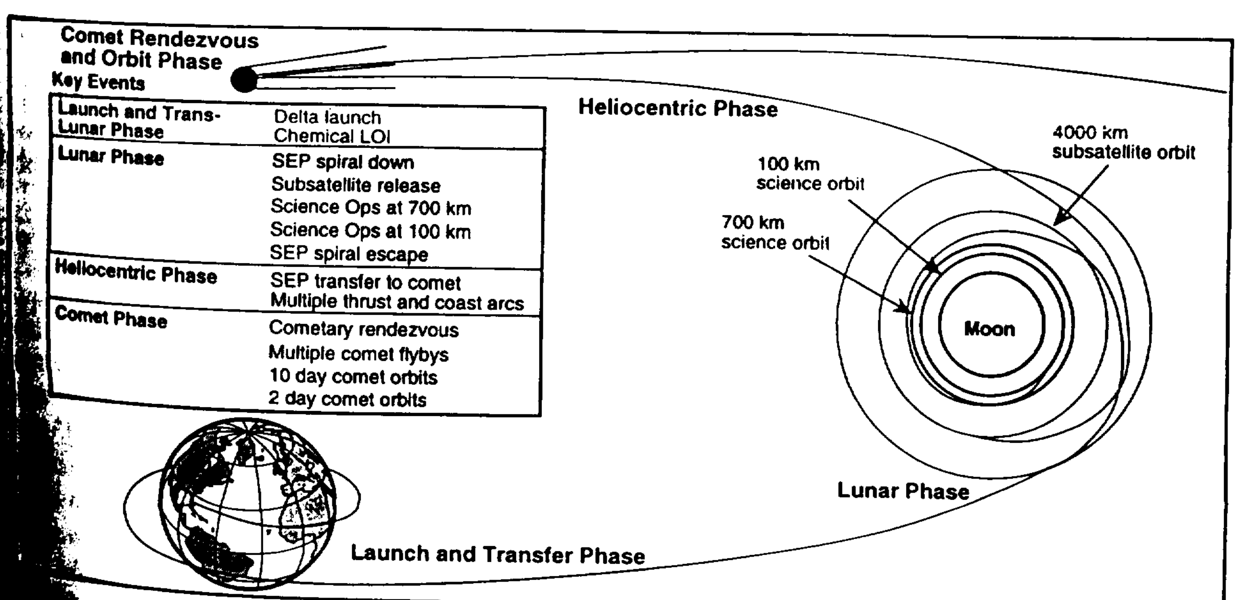
The collaboration of Dr. Carle M. Pieters was part of a project that developed rational and a detailed mission scenerio to explore the Moon and an extinct comet. Dr. Pieters' involvement focused on evaluating spectroscopy instruments and defining a mission plan to derive maximum science return. Attached are two reports that document this activity.

THE DIANA DISCOVERY MISSION: A SOLAR ELECTRIC PROPULSION MISSION TO THE MOON AND A COMET;

C. T. Russell, IGPP/UCLA; J. Abshire, GSFC; M. A'Hearn, U. Maryland; C. Alexander, A. Konopliv, A. Metzger, JPL; J. Arnold, UCSD; J. J. Berthelier, CETP; R. Elphic, LANL; M. Hickman, D. Palac, LeRC; R. Jaumann, G. Neukum, DLR; T. McCord, U. Hawaii, R. Phillips, U. Washington; C. Pieters, Brown University; W. Purdy and R. Rosenthal, TRW.

In response to the Discovery announcement of opportunity a team consisting of TRW, Lewis Research Center, JPL and UCLA with scientific co-investigators from government and University laboratories have proposed to fly the first planetary solar electric propulsion (SEP) mission. Diana is designed to carry an X-ray and gamma ray spectrometer, an imaging spectrometer, a framing camera, a laser altimeter an ion spectrometer and a magnetometer. In order to obtain lunar gravity data from the far side of the moon a relay satellite is placed into high polar orbit about the moon to relay the Doppler-shifted telemetry to Earth. Diana will spend two months in a 700 km polar orbit obtaining mineralogical data from a full spectral map of the lunar surface, and then spend a year in a 100 km (or below) polar orbit mapping the lunar elemental composition, its topography, gravity field, ions from its atmosphere and its permanent and induced magnetic fields. After the low altitude mapping phase the ion thrusters propel the spacecraft out of the lunar sphere of influence and onto a heliocentric trajectory to rendezvous with dormant comet Wilson-Harrington. The ground truth provided by the returned lunar samples to validate the remote sensing instruments for lunar studies will also serve to validate the Wilson-Harrington observations since the same instruments will be used at both bodies.

The value of solar electric propulsion to the planetary program is made evident by comparing the same mission attempted with solely chemical propulsion. Diana is launched with a Delta II launch vehicle. A similar chemical mission would require a Titan IV and would be in the Cassini class of missions. Solar electric propulsion will open up exploration of the inner solar system including the main belt asteroids by making many bodies accessible at an affordable cost.



Diana Fact Sheet

Mission Summary

Diana is a Discovery mission that will provide high priority geophysical and geochemical science data on two solar system targets: an evolved body, the Moon, and a primitive body, the nucleus of the dormant comet P/Wilson-Harrington. Diana will conduct a comprehensive orbital survey of these two bodies, and compare and contrast complementary data sets. Diana returns prime data immediately after launch and, with the two-missions-in-one aspect, has a high science return per dollar.

Diana will apply new technologies to solar system exploration, in particular xenon ion solar electric propulsion (SEP). An excellent vehicle for public awareness and educational activities, the Diana outreach program involves elementary/middle/high schools, community colleges, HBCUs.

Mission Description

The Diana launch is September 15, 2000. Lunar orbit insertion is accomplished with chemical propulsion. SEP is used for orbit circularization and achievement of three separate altitudes: 4000 km for relay subsatellite deployment, 700 km for a two month survey, and 100 km for a one year mapping mission.

After the lunar mission is complete, SEP is used to raise the orbit altitude to escape, transfer to a heliocentric orbit, and rendezvous with the comet at a solar distance of 1.9 AU. The mission ends after six months of operations in the vicinity of the comet, at distances of 3.2 AU solar and 3.5 AU to Earth.

Mission Objectives

Lunar objectives (Lunar Exploration Science Working Group priorities):

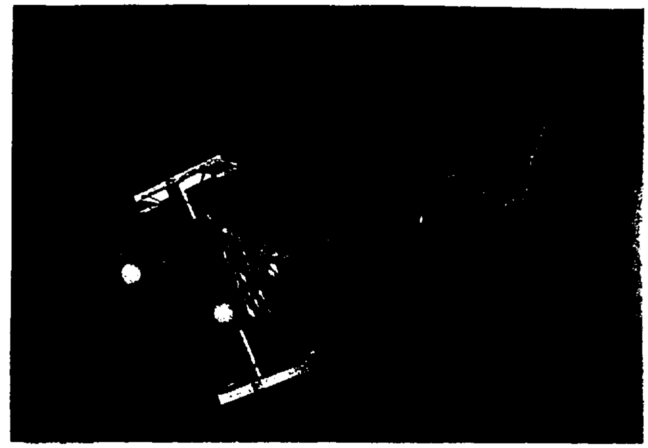
- Constrain models of lunar origin by estimating the refractory element content and ratio of magnesium to iron in the crust
- Estimate the composition and structure of the lunar crust in order to model its origin and evolution
- Determine the origin and nature of the lunar magnetic field and estimate the size of the lunar core
- Determine the nature of impact processes over geologic time and how they have modified the structure of the crust
- Determine the nature of the lunar atmosphere and the physical basis for its sources and sinks

Cometary objectives (National Academy of Science and NASA studies):

- Determine the mass and density of the comet
- Map the structure and composition of the mantle
- Determine the refractory/volatile ratio in the nucleus
- Determine the surface morphology and structure
- Measure the organic content of the crust
- Measure the volatile composition and the outgassing rate
- Determine how the nucleus interacts with the solar wind

Science Payload

Instrument	Investigation Team Leader	Mass (kg)	Power (W)
Framing Camera	G. Neukum, DLR	4	7
Imaging Spectrometer	C. Pieters, Brown U	14	42
Gamma-Ray/Neutron Spectrometer	A. Metzger, JPL	10	8
X-Ray Fluorescence Spectrometer	A. Metzger, JPL	12	8
Laser Altimeter	J. Abshire, GSFC	8	50
Magnetometer	C. Russell, UCLA	3	3
Ion Mass Spectrometer	R. Elphic, LANL	7	8
Relay Subsatellite (Gravity Science)	A. Konopliv, JPL	25	197



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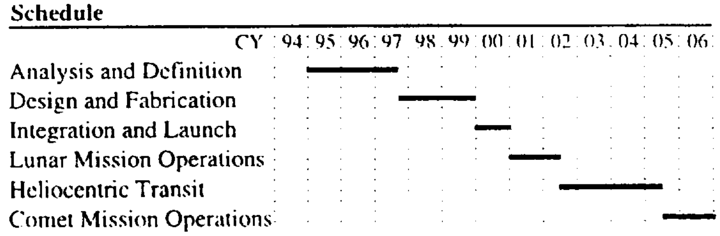
Flight System

The flight system spacecraft bus is a direct descendent of NASA's Lewis SSTI spacecraft. The SEP module uses components brought to flight readiness on NASA's NSTAR and APSA programs. Key characteristics are:

- Mass: 658 kg dry mass, 450 kg xenon propellant capacity, 102 kg hydrazine and 65 kg oxidizer capacity
- Power: solar array 7 kW @ 1AU BOL, 500 W @ 3.3AU, 65 W/kg; battery 16 A-hr dual cell NiH
- Propulsion: six 450-2300 W 30 cm xenon ion electric engines, four bipropellant 38 N and eight monopropellant 4N thrusters
- Communications: 2.2 Mbps (lunar) to 30 kbps (3.5 AU) at X-band over 1.5 m HGA through 50 W TWTA

Schedule



Schedule Reserves: design/development, net 90 days, distributed to activities; lunar orbit operations/heliocentric transit, net 25 days

Diana Mission Management

NASA Discovery Program Manager: Mark Saunders
NASA Discovery Program Scientist: Henry Brinton
Diana Principal Investigator: Chris Russell, UCLA (310-825-3188)
Diana Project Manager: Brian Muirhead, JPL (818-393-1013)
Diana Deputy Project Manager: Don Palac, LeRC (216-977-7094)

Diana Government/Industry Team

Jet Propulsion Laboratory: project management; mission operations
NASA Lewis Research Center: Phase A/B study management; mission design; science instrument acquisition
TRW Space & Electronics Group: flight system development, integration and test; launch and operations support
Jackson and Tull (an SDBC): Relay Subsatellite design, fabrication, assembly and test, and flight system support

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